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IRRIGATING CORN

in humid regions

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U.S. DEPARTMENT OF AGRICULTURE

CORNGROWERS in arid and semiarid regions irrigate at regular intervals during the growing season. Their irrigation schedules are seldom complicated by the fact that heavy rains may fall. Sometimes they find it feasible to apply preplanting irrigations to reduce the danger of early crop failure. In areas of low rainfall, germination is not possible without preplanting irrigation.

Irrigation of corn in humid regions is intended to supplement rainfall. It is seldom necessary or profitable to irrigate at regular intervals during the entire growing season. Growers usually maintain their irrigation systems on a standby basis and use them to carry their crops through critical periods of growth if drought occurs.

Preplanting irrigations in humid regions are usually unnecessary. Abundant rains during the winter and early spring generally fill the soil reservoir by planting time.

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IRRIGATING CORN IN HUMID REGIONS

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Thirty-one States make up the humid regions of the United States. The westernmost of these are the States from Minnesota southward to Louisiana. The effectiveness of irrigating corn in these regions has definitely been established.

Why irrigation helps

Unirrigated corn crops in many of these States failed in 4 of the 10 years between 1946 and 1956. Yields were sharply reduced in other years. These failures and near failures occurred primarily because too little rain fell during the growing season. Considerable amounts of rain may have fallen during the fall, winter, and early spring, but not enough during June, July, and August. In Mississippi, for example, 45 inches of rain fell during the first 6 months of 1953. After May 19, however, no rain fell for 31 days. Rainfall was abundant, but it was too poorly distributed to support the growing of corn.

In addition to poorly distributed summer rainfall, compact layers of soil in some parts of these regions add to the drought hazard. They reduce water intake from winter rains and thus limit preseason storage. Corn roots do not grow through or into these layers and the root systems developed are shallow. Only the water in the soil at root-zone depth can be utilized by the plants.

Also to be considered is the fact that the amount of plant-available water that any soil retains even under ideal conditions is limited. The approximate amounts retained for each foot-depth of representative soils in the humid regions follow:

	Inches
Sandy soils	0.7
Sandy loams	1.3
Loams	1.8
Silt loams	2.2
Clay loams	1.9
Clays	1.8

If more rain falls than the soil can retain, the excess runs off or seeps beyond the root zone of the plants. Although corn roots sometimes extend through depths greater than 3 feet, the percentage of the available stored moisture extracted by the roots below 2 feet is usually small. If a sandy loam is filled to capacity, about 3.9 inches of water would be available in the top 3 feet of soil for the corn plants. How long would this much water sustain the crop?

To know this, one must know the evapotranspiration rate—that is, the rate at which water is transpired (given off) by the corn

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Irrigated corn (A) and unirrigated corn (B) in a South Carolina experimental plot. The growing season was dry; only 2.30 inches of rain fell during July and August.

TABLE 1.—*Estimated daily evapotranspiration rates for corn, by latitude, month of the growing season, and different weather conditions*

Latitude and month	Daily evapotranspiration rate		
	Dull, cloudy weather	Normal weather	Bright, hot weather
	Inches	*Inches*	*Inches*
Between 48° and 40°, north:			
April and September	0.06	0.09	0.13
May and August	.07	.12	.18
June and July	.12	.17	.22
Between 40° and 34°, north:			
April and September	.08	.11	.14
May and August	.11	.14	.19
June and July	.14	.17	.23
Between 34° and 30°, north:			
April and September	.09	.13	.16
May and August	.13	.16	.22
June and July	.14	.17	.23

plants and the rate at which water evaporates from the soil in which the plants are growing. Daily evapotranspiration rates for different months of the growing season, for different latitudes, and for different weather conditions have been estimated. They appear in table 1. The following shows how the table is used in finding the answer to the question:

If the crop is growing in an area between 48° and 40° of latitude, north, in July (col. 1 of table) and the weather is bright and hot (col. 4), the evapotranspiration rate is 0.22 inch a day (col. 4).

If the 3.9-inch water supply is not replenished by rain or irrigation, and if the weather stays bright and hot, half of the plant-available water will be used up in about 9 days. Any reduction in water below this point can slow growth and reduce corn yields. Such low moisture is very critical for corn production from the time the plants begin to tassel until they reach the early dent stage of growth.

Summer droughts of 2 to 3 weeks in most sections of the humid regions of the United States reduce yields. A 30-day drought in midsummer without irrigation usually causes crop failures.

Corngrowers in humid regions who depend on irrigation should know when to irrigate and how much water to apply. Timely irrigation saves crops and increases yields. Untimely irrigation wastes water. If water and time are limited, however, corn may be irrigated only during the tasseling to early dent stage of growth. Research has shown that corn irrigated only during this stage usually produces yields almost equal to those of corn irrigated throughout the growing season.

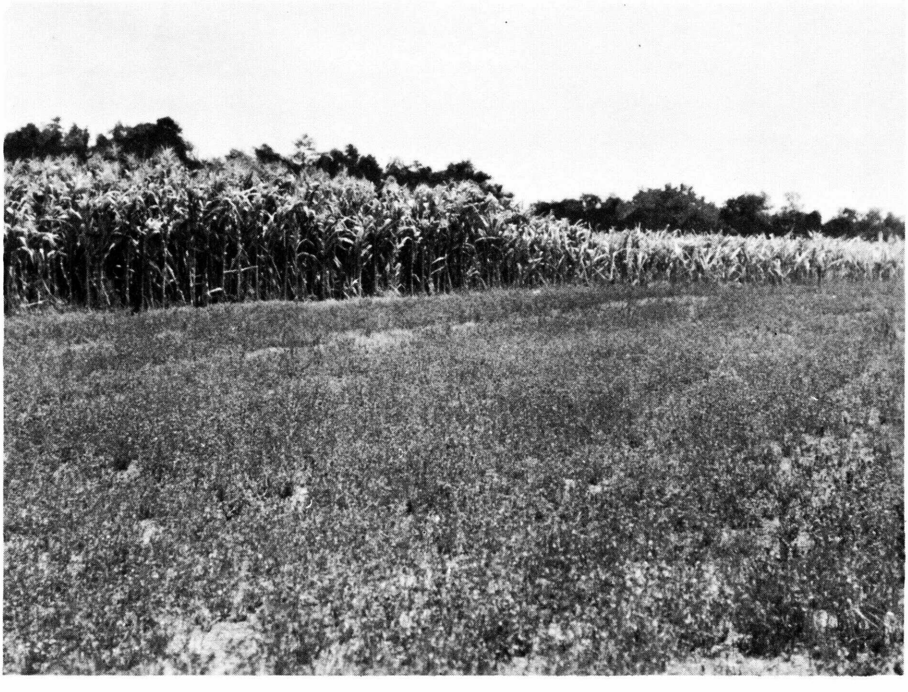
When to irrigate

Corngrowers in humid regions should be prepared to irrigate when one-half of the available supply of water in the first 2 feet of soil has been exhausted. If the available stored water is kept at or above 50 percent of soil capacity, the soil will be moist, and the corn will make maximum growth. "The first 2 feet" was selected because most corn roots occupy that area and 2 feet appears to be the maximum depth to which numerous roots permeate the soil mass.

Three methods can help you determine when one-half of the water in a given field has been exhausted. Use the method or combination of methods that suits your particular needs.

Recordkeeping method

With evapotranspiration data from table 1, together with data on the amount of rain that falls on your field, you can establish a record that shows, from day to day, the moisture "balance" of your soil.



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Plots of irrigated and unirrigated corn in South Carolina. The irrigated plot received 6.90 inches of water during tasseling to early dent stage of growth of the corn. It yielded 69 bushels to the acre. The unirrigated corn failed to attain satisfactory growth. About 6.62 inches of rain fell during the growing season.

TABLE 2.—*Example of recordkeeping to determine when to irrigate corn growing in a sandy loam field that lies between 30° and 34° of latitude, north*

Date	Evapotranspiration	Rainfall	Irrigation	Balance
	Inches	*Inches*	*Inches*	*Inches*
June:				
2		2.90		2.60
3	0.23			2.37
4	.23			2.14
5	.17			1.97
6	.23			1.74
7	.14	.13		1.73
8	.23			1.50
9	.23			1.27
10	.17		1.50	2.60

Table 2 shows an example of such a record. The grower maintains it by adding a line each day. His purpose is to compute and record the moisture balance for that day. The balance represents, in inches, the supply of water in the first 2 feet of soil. Knowing the balance enables him to determine the right time to irrigate.

The information in the "Evapotranspiration" column of table 2 is taken from table 1. The postings indicate that the weather between 34° and 30° of latitude, north, on June 3, 4, 6, 8, and 9 was bright and hot. On June 5 and 10, normal weather prevailed. On June 7, it was dull and cloudy. All these variables—the location of the field, the months of the year, and the prevailing weather conditions—affect the amount of water that a corn crop and the field in which the corn is growing evapotranspires.

The first entry in table 2 in line with June 2, and under "Balance," indicates that the soil received 2.90 inches of rainfall. This amount of water exceeds the maximum that 2 feet of this particular type of soil can hold. It establishes a balance. (The 0.30 inch is disregarded because it is assumed that some water runs off the soil or seeps beyond the root zone of the corn plants.)

From June 3 through June 6, the crop and field evapotranspired various amounts of water. These are subtracted from the balance. On June 7, the crop evapotranspired 0.14 inch of water and 0.13 inch of rain fell, which leaves a net loss of 0.01 inch of water. The balance is now 1.73 inches. On June 8, another 0.23 inch of water was evapotranspired, which brings the balance down to 1.50 inches. On June 9, the evapotranspiration brings the balance to about one-half the available moisture. On June 10, 0.17 inch of water was evapotranspired and an irrigation of 1.50 inches reestablishes the balance of 2.60 inches for the 2-foot depth.

Corngrowers in humid regions can establish their own records for irrigating purposes by following this outline:

1. Determine the texture of your soil.

2. Use the information given on page 3 to find out how much water the first 2 feet of your soil retains.

3. Establish this as a balance in the soil.

4. Use the map on page 9 and determine the degrees of latitude between which your cornfield lies. If your cornfield is near Orangeburg, S.C., for example, it lies between 34° and 30° of latitude, north.

5. Consider the month of the growing season and the weather and then check table 1 to see how much water your corn and cornfield are evapotranspiring each day. In April and September, if bright, hot weather prevails, the evapotranspiration from your corn crop is about 0.16 inch a day.

6. Make daily additions or subtractions, depending on the daily evapotranspiration rates and the amount of rainfall. The best way to determine the amount of rainfall is by setting up rainfall gages close to each cornfield. Simply constructed, inexpensive gages are available. Rainfall data reported by newspapers or on radio or TV broadcasts are not satisfactory. Fields located short distances apart often receive different amounts of rainfall.

7. Irrigate when your water balance is one-half of the maximum amount of water the first 2 feet of your soil retains.

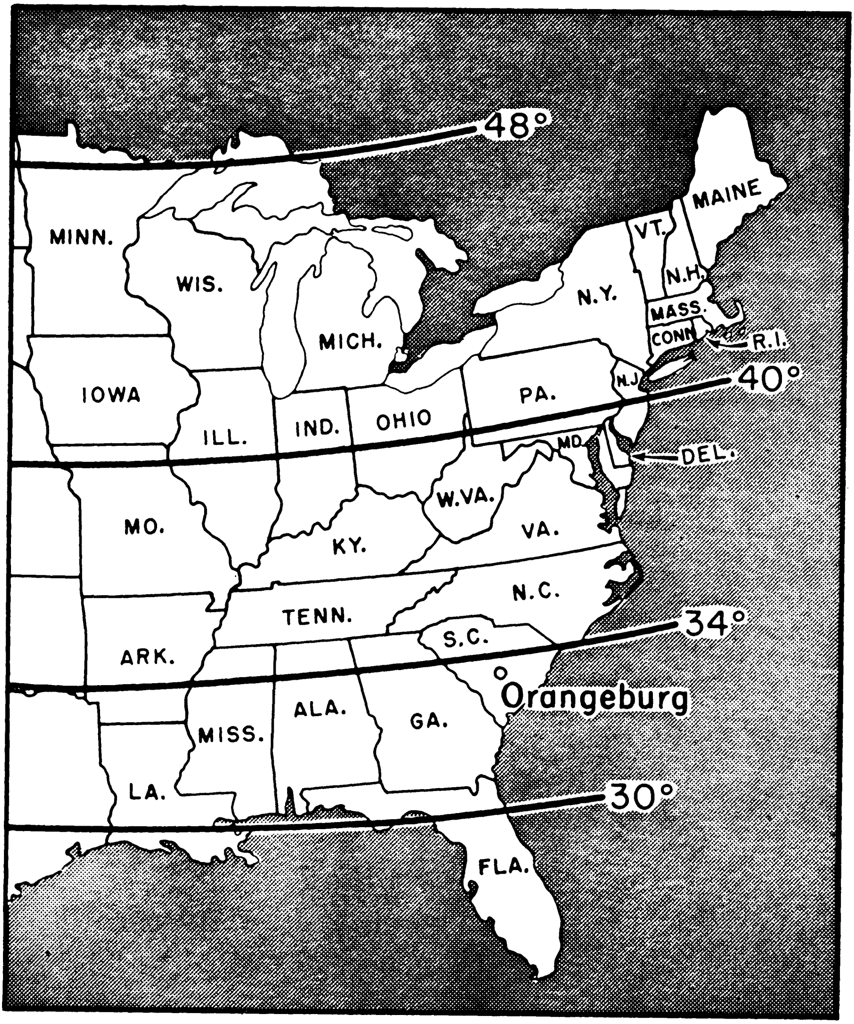
Soil-and-plant method

Select a soil sample from an area about 8 inches beneath the surface. Samples taken from or near the surface are likely to be air-dry. Manipulate the sample and try to form it into a ball. One-half or more of the available water has been removed from—

- A *sandy loam* when a sample of it cannot be formed into a ball.
- A *loam* or *silt loam* when a sample crumbles.
- A *clay* or *clay loam* when it can be formed into a stable ball that dries quickly and cracks.

After testing the soil, examine the corn plants for signs of wilting. When about one-half the water in the soil has been exhausted, corn usually wilts in the afternoon, but recovers overnight. Make allowances for exceptionally high temperatures and low humidity. These conditions also cause corn to wilt even though the amount of available water in the soil is above the minimum needed for satisfactory growth.

Do not delay irrigating when the soil or plants show signs of water shortage, particularly when the corn is in the tasseling to early dent stage of growth.



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Map of the humid regions of the United States showing degrees of latitude, north. Orangeburg, S.C., is shown because, on page 8, reference to that place serves as a means of illustrating how to use the map.

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Using a tensiometer to determine soil moisture.

Instrument method

Tensiometers and electrical resistance cells can be used to estimate how much water is in the soil. These instruments are available commercially. Your dealer or your county agent can tell you how to operate them. If carefully calibrated, most of them are satisfactory.

Irrigation methods

Two methods of irrigation are generally used in humid regions—the furrow method and the sprinkler method. The sprinkler method is preferable if your soil is deep and sandy and if it takes water readily. Sprinklers are also best on rolling land, on steep slopes, and where grading to cut down ridges and knolls removes too much fertile soil.

Use the furrow method if your land is level or if it slopes about 1 foot for each 200 feet.

Consult a technician of the Soil Conservation Service (United States Department of Agriculture) or your county agent before you select an irrigation method or buy any equipment.

Sprinkler method

A sprinkler system should be large enough to do the job, but not too large. Oversize systems are not economical. (The sprinkler method of irrigation is illustrated on the cover of this bulletin.)

Where the water comes from, its distance from the field, and the nature and size of the fields to be irrigated determine the layout of the system. If you have a choice, irrigate fields that are close to the water supply. Irrigation costs with sprinkler systems increase as pumping distance and operating pressures increase.

Consider economy and the distribution requirements when selecting the size of pipe. The larger the pipe diameter, the more the pipe costs. But using pipe sizes that are too small merely to cut down initial costs may be false economy. Under the same operating conditions, a pipe that is 1 inch in diameter delivers less than half as much water as a pipe that is 2 inches in diameter. This is true because the area of the 2-inch pipe is four times greater than the area of the 1-inch pipe.

How the main and lateral lines are arranged is important. They should be large enough and extensive enough to distribute the water evenly and rapidly. Some farmers can use small systems economically and operate them continuously for 16 to 20 hours, which has some advantages.

Night operation is sometimes better than day operation because night temperatures are lower and the humidity is usually higher. Low temperature and high humidity reduce evapotranspiration losses. However, the gains in efficiency from night operation are sometimes offset by higher labor costs.

Night operation is desirable if strong winds occur during the day. Sprinklers distribute water poorly during windy weather, and operation at such times should be avoided.

Moving sprinkler systems in tall corn is difficult and expensive, unless mechanical aids are used. Leaving alleys in cornfields to facilitate the laying and transporting of sprinkler lines reduces installation costs, but some productive land is sacrificed.

The rate at which sprinkler irrigation systems apply water can be accurately controlled. The rate of application, however, should never exceed the soil's capacity to absorb water. If this capacity is exceeded, the surface soil puddles. Puddling reduces intake rates, seals the soil surfaces, which causes runoff and impaired aeration, and increases evaporation rates.

Furrow method

Pipeline systems or canals and ditches convey water to the fields when the furrow method of irrigation is utilized. The pipelines are often operated under low pressure, but canals and ditches are laid out in such a way that the water flows by gravity.

It costs more to install pipelines than it does to dig ditches. But maintaining ditches for an extended period *may* cost more than pipelines. Unburied pipes are difficult to cross. They are an inconvenience when farm machinery is operated in the same field.

1748

Gated pipe distributes irrigation water evenly.

Surface pipelines have to be assembled where needed. When the supply of pipe is limited, the lines have to be disassembled and moved as the irrigation progresses across a field or from field to field.

Buried pipelines are expensive. However, their durability and the convenience attained in using them may more than offset the initial cost of installing them. Gated pipes are used to distribute water from the main pipelines to the furrows.

Ditches and canals take more land out of production than pipelines do. Ditches and canals are also inconvenient to cross with farm machinery and equipment.

Seepage losses from ditches may occur if the soil is sandy or gravelly. Lining ditches in sandy soils with cement, plastic, or other material is usually necessary to control seepage. Seepage and distribution losses increase when weeds and soil clog the ditches. If you furrow irrigate, avoid this waste. Maintain ditches and keep them free of debris.

The use of siphons is probably the best way to distribute water from the ditches to the furrows. By adjusting the size and number of siphons to each furrow, you can control the rate of flow and distribution of water. If a field

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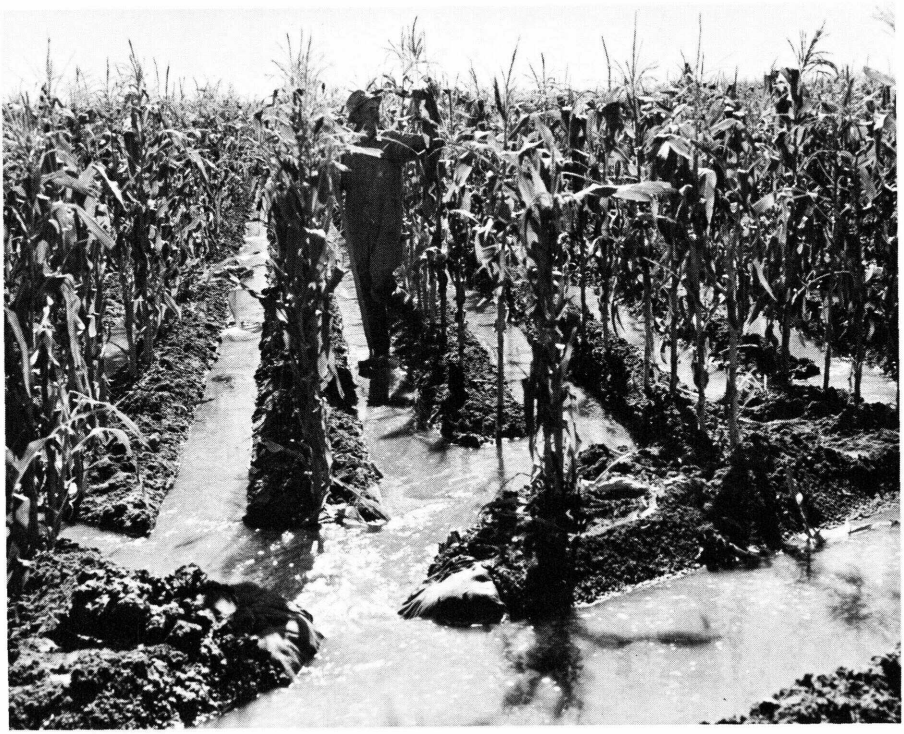
Furrow irrigation. Siphons are used to distribute the water from the ditch to the furrows.



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Furrow irrigation. The irrigator is using a canvas weir to achieve controlled distribution of the water from the ditch to the furrows.

slopes a little more than 1 foot for each 200 feet, control the slope of the furrows by grading them across the field slope. Choose the direction of flow to give the closest and most convenient access to the main supply ditch.

When cornfields are furrow irrigated, drainage is sometimes a problem. Excess water at the lower ends of the furrows must be disposed of. Water that ponds in the furrows may damage the crop. Furrows should slope at least 1 foot in every 2,000 feet in the direction of flow to take care of surface drainage.

How fast water is applied in furrow irrigation depends on how fast the soil takes in water, the space between the rows, the length of the rows, and how much water is turned into each furrow. Usually, the water should reach the lower end of the furrow in about one-fourth the time needed to irrigate the field. When the water nears the lower end of the furrow, reduce the rate of flow to avoid waste.

If you use gated pipe or siphons, you can control the water and adjust its rate of flow easily. If you make openings to the furrows in

the field ditches or delivery laterals, place adjustable weirs made of stakes or other restrictive devices in the openings. Check and adjust the weirs to regulate flow as needed to prevent washouts and erosion damage.

Making irrigation pay

The fact that corn is irrigated is not a guarantee that yields will be satisfactory. Good management practices must be followed. Some of these practices are discussed below. Consult your county agent or your State agricultural experiment station if you have any questions about them.

1. Plant only adapted varieties. Some corn varieties grow well in the coastal areas, but are poor producers in the Piedmont and mountain areas. Other varieties are adapted to bottom lands. If they are planted on uplands, they may not do well.

2. Obtain suitable stands. Twelve to fifteen thousand plants per acre, growing in rows 40 inches apart, appears to be the ideal arrangement for humid regions. If you have less than 12,000 plants per acre under irrigation, you may be wasting your soil and water resources. If seed for more than 15,000 plants is planted per acre, however, the resulting plants may be tall, spindly, and weak. Such plants have a tendency to lodge easily. Corn plants in overpopulated fields develop small ears. Prolific varieties may set but one ear per stalk.

3. Fertilize adequately. One hundred to one hundred and fifty pounds of nitrogen per acre per season is usually needed. Potassium and phosphorus may also be needed. Base your rate of application on soil tests or follow the recommendations of your State agricultural experiment station.

4. Apply lime as needed to regulate soil acidity. A pH between 6.0 and 6.5 is recommended. Use either dolomitic or calcic limestone; the choice depends on the soil's need for magnesium or calcium. Here again, rely on soil tests or follow the recommendation of your State experiment station.

Other information

Irrigation may or may not affect lodging. Irrigated corn usually has good root systems and can withstand winds. Winds that occur when the soil is wet may cause some lodging, however.

Ample soil moisture causes most corn varieties to mature early.

In some areas, high temperatures (93° to 99° F.) during periods of drought may cause "baking" of tassels, even where crops are irrigated. Poor pollination results.

Air temperature usually drops when it rains, but it is not greatly influenced by irrigation.

Decreased sunlight may retard corn growth.

Areas under clear summer

skies support thicker growth when irrigation is practiced than areas where cloudy weather is prevalent.

Irrigation Guides for each State, compiled by the Soil Conservation Service, United States Department of Agriculture, are excellent sources of technical information for developing and operating irrigation systems. The Guide developed for South Carolina, for example, describes the State's soil profiles. It gives suitable application rates, which were developed from experimental intake rates. It provides data on how much water should be applied to replace water used. Data on root zone depths and peak use of moisture by most plants that may be irrigated are shown. Recommended application rates can be increased to some extent under mulch tillage and on some very sandy soils on 1- to 2-percent slopes. However, extreme caution should be exercised in selecting rates of application other than those given.

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